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RESEARCH PAPER

Rate of timber production in a tropical rainforest ecosystem of South-western Nigeria and its implications on sustainable forest management

V. A. J. Adekunle • A. O. Olagoke • L. F. Ogundare

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Abstract: Timber harvesting data are very essential for sustainable management of forest resources. These data are very scarce in developing countries. Therefore, we collected and analyzed data on the rate of timber production of the free areas and the forest reserves in Ondo State, Nigeria. The data collected from the State Department of Forestry's official records, annual reports and files were on the species, volume and number of different economic timbers exploited on monthly basis between 2003 and 2005. Analyses were done with the student t-test and one-way analysis of variance. Results reveal that the highest numbers of species, families and stems were exploited in the free areas when compared with what was exploited from the reserves for the three-year period. However, the total volume of trees removed from the reserves was significantly higher (p<0.05) than what was removed from the free areas. A total 60 different indigenous hardwood species in 25 families were exploited from the free areas, and 57 in 23 families from the reserves. The total number of stems exploited from the forest ecosystem of Ondo state during the three-year period stood at 111 377 with an estimated volume of 295 089.67 m^3. While the mean number of stems and volume exploited per annum is 37 125 and 98 363.22 m^3, respectively. The monthly average number of stems and volume is 3 094 and 8 196 m^3, respectively. The t-test results show that there were significant differences (p<0.05) in number of stems and volume removed from the free areas and the reserves. The ANOVA results reveal a significant increase (p<0.05) in logging activities between the years of 2003 and 2004 but there was a decline in year 2005. This trend reveals that economic timber species were disappearing from the forests and the ecosystem was seriously disturbed during logging activities. Principles for achieving the goals of sustainable forest management (SFM) and urgent conservation measures to mitigate the consequences of forest degradation were suggested.

Keywords: conservation measures; forest estate; illegal logging; sustainable forest management; timber harvesting

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V. A. J. Adekunle. • A.O. Olagoke. (✉)
Federal University of Technology, Department of Forestry and Wood Technology, Akure, Nigeria. Email: adewoleolagoke@gmail.com

L. F. Ogundare
Ondo State Ministry of Agriculture, Forestry and Fisheries, Forestry and Wildlife Services, Akure, Nigeria.

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Introduction

Reservation of Nigerian forest estates began in 1899 when it was realized that the frequent forest harvesting as a new enterprise might result in environmental hazard and scarcity of wood in the future. Ogunlade (1993) noted that one third of Nigeria land area (983 213 km^2) was covered by forest from where just 10% was successfully put under reservation. Nigeria has a total of 1 160 of such constituted forest reserves covering a land area of about 1,075 km^2. Most of these reserves only exist today on paper (Salami 2006). All other woodlands apart from the 10% under reservation are regarded as free areas (Adetula 2008). A total land area of about 914 km^2 is designated as free areas in Nigeria.

Though the Federal Government of Nigeria, through its body responsible for the management of forest resources, puts deforestation rate to be 3.5% (Oyebo 2006), but Salami (2006) estimated the present rate of deforestation in Nigeria to be 1.36% per annum. Timber harvesting had remained a big business to quite a number of people with its attendant forest destruction and deforestation right from the colonial era. While felling and sawing of logs are going on, other tangible Non-Timber Forest Products (NTFPs) are also harvested by mere collection. These NTFPs include fruits (from *Irvingia gabonensis),* gums, resins, tannins, dye, medicinal plants, mushroom, snails, and *Thaumatoccocus danielii* and leaves of *Mitragyna stipulosa* commonly used for preservation of cola nuts and wrapping. Timber harvesting has been going on in Nigerian forest ecosystem without any deliberate management programmes for more than fifty decades. Although the tropical forest, where these resources are got, appears luxuriant because new leaves grow continually and there is no dormant season when all the leaves are shed, one should not be deceived to believe that the forest is still there.

In Nigeria today, forest management is at crossroads because the guiding principles of managing the forest sustainably are no

more existing. Challenges like illegal activities in the forest, declining manpower and capacity in Forestry Department, inadequate forest patrol, stoppage of the payment of annual royalty (formerly 5% of total income) from what accrued from logging activities to rural communities, outdated forestry laws and regulations, and population increase are grave threat to sustainable forest management (SFM) in the country today (Adetula 2008). Population increase has increased the pressure on forestland for cultivation of arable and tree crops. SFM, a system of management that gives room to the judicious harvesting and utilization of forest resources without jeopardizing the future, is the pillar behind forest management in developed counties. SFM was defined as the stewardship and use of forests and forestlands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfill, now and in the future, relevant ecological, economic and social functions, at local, national, and global levels, and that does not cause damage to other ecosystems (Briner 2004).

The data on the rate of timber production and harvesting in Nigeria are deficient due to poor record keeping system and the blithe attitude of Nigerian civil servants. Where these data are available, they are not well studied and analyzed. As a result, it has been so difficult to compare the rate of forest harvesting with the regeneration potential of the natural forests. This would have formed the premise on which forestry planning and development should rest like in the developed nations that have committed substantial amount of fund to monitor growth and harvesting in their natural forests and plantations. Consequently, there is the need to carry out a field research for estimating the rate at which economic tropical hardwood timber species are removed from the tropical forest ecosystem of Nigeria. This work therefore assessed the rate of timber harvesting in tropical rainforest ecosystem of Nigeria, using Ondo State as a case study, and its consequences on sustainable forest resources management.

Materials and methods

The study area

The study was conducted in Ondo state, Nigeria. Ondo state covers an area of about 14,788.728 km^2 and lies in the tropical rainforest zone with the longitudes 4°30'–6°0' E and latitudes 5°45'–8°15' N (Fig. 1). The climate is the humid sub-tropical. The forest is multilayered with dominant broadleaved trees (whose height could be up to 50 m), climbers and lianas. The trees are green throughout the year because the temperature and precipitation are sufficiently high for continuous growth. The state has about 16 forest reserves, out of which 13 reserves (covering a total land area of about 1 273 km^2) were designated to be viable by the time organized forestry started between 1930 and 1936 in Nigeria.

Data collection

Secondary data on the volume and the number of economic timber species extracted on the monthly basis between 2003 and 2005 for the reserved and unreserved forests (free areas) in four forestry administrative zones- Owo, Idanre, Akure and Ofosu - in the state were collected from the state Department of Forestry official records, files and annual reports.

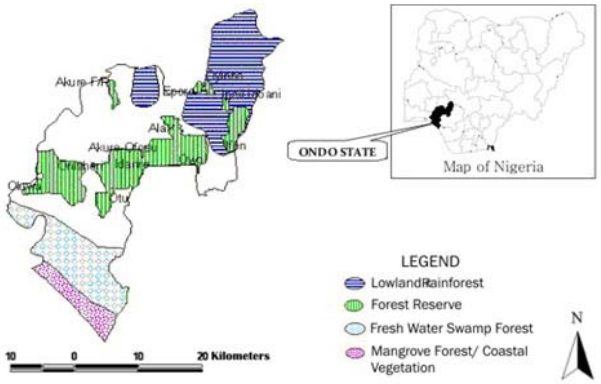

Fig. 1 Map of Ondo State showing forest locations with map of Nigeria in inset

Data analysis

The data were analyzed separately for both forest types (reserves and free areas) on monthly basis throughout the period of study. The total, annual and monthly average of volume and number of trees exploited were determined for entire study area. All the species exploited from both reserved and unreserved forests were classified into families and the total number of species in each family was determined. One-way analysis of variance (ANOVA) was used to test for significant differences in the number of stems and volume extracted between 2003 and 2005 in the study area. In addition, the student t-test was used to compare and test for significant differences in the number of stems, tree species diversity, family richness, and volume exploited in the free areas and the reserves. The analyses were carried out using Statistical Package for Social Science (SPSS) for windows 13.0 (SPSS, 2003).

Results

The results of this study showed that a total of 111,377 stems, belonging to 62 different indigenous hardwood species of tropical rainforest ecosystem were exploited from the entire study area between 2003 and 2005 (Table 1). These species were distributed among 16 families. According to Table 1, 37,125 stems were removed annually while 3,094 stems were harvested per month. The total volume of the timbers removed during the three-year period from the state forest ecosystem was estimated to be 295,089 m^3 (i.e. 140,896.21 and 154,193.46m^3 from the forest reserves and free areas, respectively). The mean annual and monthly volumes of the removed timbers therefore stood at 98,363.22 and 8,198.94 m^3, respectively.

From Table 1, the number of individual tree species exploited from the free areas was higher than that of the forest reserves, except for some species like *Afzelia africana, Bombax buonopo-*

zense, Cordia millenii, Lovoa trichilioides, Mansonia altissima, Mitragyna ciliata, Nauclea diderrichii, Nesogordonia papaverifera, Sterculia rhinopetala and *Terminalia superb*. *Pterocarpus spp was* the least exploited species from the forest reserves throughout the period of study. Five species namely *Borassus aethiopicum, Gossweilerodendron balsamiferum, Carapa procera, Irvingia spp* and *Millettia spp* were exclusively exploited from the free areas. These important species are already lost from the reserves. Therefore, loggers interested in any of those not available in the reserves again have to search for them in the free area forests.

Table 1. Tree species felled in free areas and the reserves in the study area between 2003 and 2005.

Species	Free Areas		Forest Reserves		Total
	Free Areas	Forest Reserves	Free Areas	Forest Reserves	Volume (m^3)
Afromosia elata	8	18.68	52	126.48	145.16
Afzelia africana	962	2348.52	5070	19783.4	22131.92
Albizia ferruginea	2017	4218.66	125	391.74	4610.4
Albizia zygia	352	1074.4	21	65.72	1140.12
Alstonia boonei	3423	7756.88	117	511.46	8268.34
Amphimas pterocarpoides	510	1183.1	20	60.03	1243.14
Antiaris africana	4494	10404.73	187	545.16	10949.89
Azadrachta indica	0	0	12	37.18	37.18
Berlinia confusa	178	408.37	53	133.58	541.95
Blighia sapida	259	555.42	10	30.13	585.55
Bombax buonopozense	202	1475.21	231	955.56	2430.76
Brachystegia eurycoma	1663	5474.52	1030	3968.76	9443.28
Borassus aethiopicum	5	4.2	0	0	4.2
Canarium schweinfurthii	612	1333.28	19	49.73	1383.01
Carapa procera	12	26.94	0	0	26.94
Ceiba pentandra	3806	12288.81	1000	4148.25	16437.06
Celtis zenkeri	1697	3473.64	176	548.74	4022.38
Chrysophyllum pelpulchrum	875	2030.92	408	1267.34	3298.26
Combetrodendron	20	39.92	4	16.52	56.44
Combetrodendron sp.	18	35.25	4	16.52	51.77
Cordia mellinnii	1384	3073.61	7661	23244.53	26318.14
Danielia ogea	711	1632.54	42	137.11	1769.65
Dialium dinklagei	2385	5271.67	5	14.04	5285.71
Distemonanthus benthamianus	103	255.75	23	67.97	323.73
Entandrophragma cylindricum	867	1955.4	99	336.94	2292.34
Entandrophragma utile	159	473.11	1	1.96	475.07
Erythrophilleum ivorense	303	623.52	284	1004.74	1628.26
Fagara zanthoxyloides	300	623.9	13	44.82	668.73
Ficus sp.	1822	4050.34	5	14.39	4064.72
Funtumia elastica	13	28	3	7	35
Gmelina arborea	27	27.02	50	119	146.02
Gossweilerodendron spp	3	6.93	0	0	6.93
Guarea cedrata	57	109.76	34	86.51	196.27
Hannoa Klaineana	542	1165.12	41	129.19	1294.31
Holoptelia grandis	806	1714.59	420	1288.11	3002.7
Irvingia wombulu	3	5.88	0	0	5.88
Khaya sp.	2799	5994.49	288	890.03	6884.52
Lannea welwitschii	996	2350.63	167	539.81	2890.44
Lonchocarpus sp.	97	234.98	35	98.56	333.54
Lophira alata	173	483.4	21	76.26	559.66
Lovoa trichilioides	39	86.74	50	122.77	209.52
Mansonia altissima	1379	2503.87	7407	16276.49	18780.36
Melicia excelsa	4080	10263.16	223	922.66	11185.81
Milletia thonningii	2	5.46	0	0	5.46
Mitragna ciliata	104	237.19	137	414.74	651.93
Mitragyna stipulosa	54	108.57	4	13.39	121.96
Nauclea diderichi	36	72.01	277	810.96	882.96
Nesogodonia papaverifera	607	1935.82	1202	3285.51	5221.33
Phyllanthus discoideus	139	356.13	2	7.23	363.36
Pipetadeniastrum aficana	602	1462.97	61	232.17	1695.14
Pterocarpus sp.	146	306.39	1	2.8	309.19
Pterygota macrocapa	1555	3565.6	1010	2863.78	6429.38
Pycnanthus angolensis	1013	2170.91	47	121.82	2292.73
Ricinodedron heudelotii	159	401.77	150	418.32	820.09
Sterculia oblonga	35	82.74	97	249.17	331.91
Sterculia rhinopetala	1148	2346.4	6512	17164.54	19510.94
Tectona grandis	10	18.24	1	2.93	21.17
Terminalia ivorensis	961	2113.86	878	2899.88	5013.75
Terminalia superba	4873	9169.86	7047	23056.21	32226.07
Triplochiton sceleroxylon	8151	16930.09	7650	24262.41	41192.5
Other sp.	1019	2526.34	115	308.43	2834.77
Total (three-year period)	60775	140896.21	50602	154193.46	295089.67
Annual	20, 258	46, 965.40	16,867	51,397.82	98, 363.22
Monthly	1,688	3,913.78	1,406	4,283.15	8,196.94

Timbers exploited from both the free areas and forest reserves in the study area from 2003-2005 belong to 25 distinct families (Table 2). Highest number of species (8) was exploited in the Caesalpinoidae family from both the free areas and the forest reserves, followed by Meliaceae family where seven and six different species were exploited from the free areas and the forest reserves, respectively. Six distinct species were also exploited in Sterculiaceae family from both the forest types. Apocynaceae, Mimosoidae, Moraceae and Rubiaceae families were represented by three species from both the forests while Papilionoidae had three species in the free areas and two species in the forest reserves. Apart from Bombacaceae, Combretaceae, Euphorbiaceae, Lecythidacaea, Ulmaceae and Verbenaceae that were represented by two species each from both the free areas and forest reserves, the rest families were represented by one species. No timber species was exploited in Pandanaceae and Irvingiaceae in the forest reserves throughout the study period. The largest number of stems was exploited in Ulmaceae (9 848) and Sterculiaceae (16 269) from the free areas and forest reserves, respectively. Similarly, highest volumes of timber were also extracted from both the families. Only three and five stems were exploited in Irvingiaceae and Pandanaceae, respectively, in the free areas while the least exploited family in the forest reserves was Lecythidaceae (8 stems). The least volumes of timber were extracted in the Pandanaceae (4.20) and Sapindaceae (30.13) families, respectively.

Generally, more woods were harvested from the free areas than the forest reserves. The numbers of stems, species and families of timber species extracted from the free areas were higher than that of the forest reserves. The results of the t-test showed that there was significant difference (p<0.05) in the number of stems from the free areas and the reserves in 2003 (Table 3), though there was no significant differences in the number of stems extracted from both sites in 2004 and 2005, respectively (p>0.05). Also, there was a significant difference in the family distribution of timbers exploited from the reserves and free areas

in 2005, but no significant variation occurred for 2003 and 2004. Meanwhile, the number of stems and the corresponding volumes did not varied significantly between the free areas and forest reserves across the years.

Table 2. Family distribution of timber species exploited in the study area between 2003 and 2005.

Family name	Free Areas			Forest Reserves		
	No of Species	No. of Stems	Volume (m3)	No of Species	No. of Stems	Volume (m3)
Anacardiaceae	1	996	2350.63	1	167	539.81
Apocynaceae	3	3533	8019.86	3	155	617.02
Bombacaceae	2	4008	13764.01	2	1231	5103.81
Boraginaceae	1	1384	3073.61	1	7661	23244.53
Burseraceae	1	612	1333.28	1	19	49.73
Caesalpinoidae	8	6815	17198.01	8	6527	25169.62
Combretaceae	2	5834	11283.72	2	7925	25956.09
Euphorbiaceae	2	298	757.90	2	152	425.55
Irvingiaceae	1	3	5.88	0	0	0
Lecythidaceae	2	38	75.17	2	8	33.04
Meliaceae	7	3879	8543.61	6	450	1388.89
Mimosoidae	3	2426	5402.82	3	180	543.97
Moraceae	3	6918	15918.03	3	253	791.72
Myristicaceae	1	1013	2170.91	1	47	121.82
Ochnaceae	1	173	483.40	1	21	76.26
Pandanaceae	1	5	4.20	0	0	0
Papilionoidae	3	15	28.34	2	52	126.48
Rubiaceae	3	304	652.15	3	142	430.93
Rutaceae	1	300	623.90	1	13	44.82
Sapindaceae	1	259	555.42	1	10	30.13
Sapotaceae	1	875	2030.92	1	408	1267.34
Simaroubaceae	1	542	1165.12	1	41	129.19
Sterculiaceae	6	5266	11599.55	6	16269	39968.67
Ulmaceae	2	9848	20403.73	2	7826	24811.15
Verbenaceae	2	843	5188.23	2	596	1836.86
Others	-	1019	2526.34	-	115	308.43

Table 3. Comparison of timber exploited in free areas (FA) and forest reserve (FR) in the study area with Students' T-test

Year		No. of Species	No. of Families	No. of Stems	Volume (m^3)
2003	FA	28.0±3.7	14.26±1.7	803.6±311.1	1476.0±418.7
	FR	16.9±1.1	9.89±0.4	371.8±206.7	898.5±442.2
	t-test	0.04*	0.09ns	0.30ns	0.38ns
2004	FA	17.4±7.6	13.9±2.15	630.5±303.2	1539.9±732.9
	FR	14.2±2.4	8.7±1.2	452.5±194.4	1818.5±1070.0
	t-test	0.72ns	0.13ns	0.70ns	0.84ns
2005	FA	30.6±3.7	15.3±1.9	669.9±338.0	1498.6±727.4
	FR	13.8±2.4	8.4±1.4	374.5±270.2	1224.0±974.5
	t-test	0.82ns	0.04*	0.53ns	0.83ns

Values are means of 12 replicates i.e. total harvesting on monthly basis

*Significant (p<0.05); ns= Not Significant (p>0.05)

The results of the one-way Analysis of Variance (ANOVA) for comparing the number of stems and the volumes of wood extracted for the three years involved are presented in Table 4 and that of the mean separation with LSD in Table 5. Besides the volume of wood that varied significantly (p<0.05), there was no significant difference in the number of tree stems exploited between 2003 and 2005 in the entire study area. From Table 5, the number of stems exploited in 2004 measured up with that of 2003 and 2005. However, number of stems exploited in 2003 and 2005 differed significantly (p>0.05).

Figs. 2 and 3 show the trends in the number of stems and volume exploited respectively in the free areas and forest reserves from 2003 and 2005. Timber production varied from January to December. The number of stems extracted ranged from 12 726 stems (in Feb.) to 5 413 stems (in October). In term of volume, highest volume was exploited in June, followed by March, and the least in October. Generally, logging activities is usually high during the dry season (between Sept. and April of the following year). This could be attributed to the good condition of roads and favourable forest environment during the dry season.

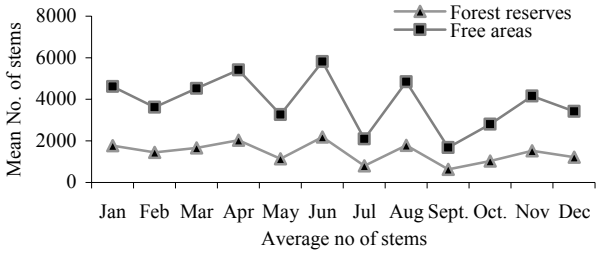

Fig. 2 Average number of stems exploited in free areas and the reserves on monthly basis

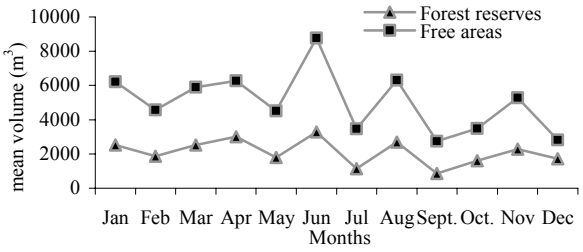

Fig. 3 Average Volume (m3) of timber exploited in free areas and the reserves on monthly basis

Table 4. Results of One-way ANOVA for comparing the number of stems and volume (m^3) exploited during the three-year period in Ondo State, Nigeria

Variable	Source of Variation	Sum of Squares	df	Mean Square	F	Sig.
No of Stems	Years	3951097.06	2	1975548.53	1.39	0.26
	Error	46990960.58	33	1423968.50		
	Total	50942057.64	35			
Volume (cubic metres)	Years	77971548.72	2	38985774.36	3.91	0.03
	Error	329310419.50	33	9979103.62		
	Total	407281968.22	35			

Table 5. Mean separation results of number of stems and volume (m^3) of timber exploited during the three-year period using the LSD

Year	Mean number of stems Harvested	Mean Volume of timber Harvest
2003	2868.00^{a}	6661.16^{a}
2004	2948.17^{a}	10177.59^{b}
2005	3607.42^{a}	7732.00^{ab}

Means sharing the same superscript in column are not significant (p>0.05)

Discussion

Timber production in the tropical rainforest ecosystem, if not well planned is very deleterious to the environment and biological diversity conservation (Fuwape 2001). The increasing rate of timber harvesting from the free areas and reserves as revealed in this study is inimical to the realization of the objectives of sustainable forest management in Nigeria. Generally, is the main problems of forest management in Nigeria include high rate of indiscriminate logging, over allocation of reserves to contractors, reckless felling of logs in the free areas and the allocated plots, and weak control of felling in the free areas, etc. High demand for timber products has resulted in the over-harvesting and complete devastation of the standing stock of indigenous hardwood species in Nigerian forests (Okpo 1996).

It should be noted that the results of this study were based on legally felled logs from available official records, annual reports and files in the state forestry service. Data on the quantity and quality of timber illegally extracted from the forests are not available. Illegal logging is very prevalent in many developing countries to the extent that what is taken out of the forest estate illegally could even be more than what is legally removed. Illegal logging in Nigeria is due to corruption, youth unemployment, inefficient control of logging activities by the government agents and weak enforcement of forest laws. In the study area, for instance, there is a Joint Task Force on forestry (with some armed police officers and military men), which provide security back up to the Department of Forestry to put in check the activities of some armed gangsters who are illegal loggers in the state (Adetula 2008). Illegal activities are serious setback to SFM in Nigeria.

The limited control of the government on logging activities in the free areas is the reason behind the huge number of stems harvested during the three-year period that is significantly (p>0.05) more than what was removed from the reserves. The findings of this study corroborate the results of Akindele and Fuwape (1998), who reported that the lower proportion of timber harvested from the forest reserves could be attributed to the control on logging timber resources within the forest reserves. The enforcement of the logging policy that prohibits the cutting of undersized trees (dbh > 48 cm) also contributed to the fewer number of stems extracted from the reserves.

There is pertinent control on logging activities in the country's forest reserves. Forest reserves are divided into compartments and loggings are carried out in each compartment according to the laid rules by the allottees. Falaye et al. (2006) asserted that only few forest allottees had allocations in forest reserves due to the exorbitant cost and inevitable bureaucracies. Timber contractors who could not afford the cost of securing allocation in the reserve usually search for wood in the free areas.

Variation in the number of stems exploited for each of the species and families gave an indication that timber contactors prefer the economic, durable and high quality timber to the less durable ones. This is in conformity with the report of Akindele and Fuwape (1998) that timber merchants are very selective in terms of tree species they search for and fell. This was manifested in their preference for species like *T. scleroxylon (Obeche), T. superba (Afara), Afzelia africana (Apa), Mansonia altissima (Ofun), Melicia excelsa (Iroko)* and the mahoganies (*Khaya spp*). These species are critically sought for by loggers to the extent that 'under-girths' are felled anywhere they are found contrary to the Nigeria logging policy. Today, these important hardwood timber species are not only rare, but they are seriously threatened with extinction. This was responsible for why their felling was banned in some States of Nigeria (FORMECU 1999). Their relative abundance was reported to be less than 5/ha in tropical rainforest ecosystem of southwestern Nigeria (Oyagade 1997; Onyekwelu et al. 2005; Adekunle 2006).

The wide discrepancy in the number of stems and volumes of trees exploited from month to month accentuate the impacts of climatic conditions on logging activities in the tropic. It was observed that timber harvesting was more intense during the dry season and in the months when rainfall was less frequent. Timber harvesting drastically reduced as rainfall became more intense. Nigeria has bad roads and poor road network. They are not usually motorable, especially to timber trucks, throughout the year. The tropical ecological zone of southwestern Nigeria where this study was carried out is characterized by heavy rainfall and long rainy season. During this season, erosion, flood and seasonal streams destroy roads, making access to the forest to be very difficult. These are great impediments to timber harvesting, skidding, and transportation. Therefore, loggers take the advantage of the dry season to exploit more trees.

The current level of demand for wood is more than the sustainable level of supply. What is removed has been reported to be far beyond the natural capacity of the forest to recuperate in order to continue its normal functions (Olajide et al. 2008). Oyebo (2006) predicted that there is the possibility of an annual deficit of about 80 million to 100 million m^3 in the supply and demand for wood from the year of 2005 to 2020. The negative economic, ecological and environmental impacts of logging are very grave. Continuous harvesting without adequate regeneration strategies will lead to structurally and genetically degraded forest, which are extremely difficult and expensive to rehabilitate. This calls for revisiting and implementing the basic principles of sustainable forest management (SFM) which is the only way forward to save Nigerian forest from total collapse.

For forest managers, sustainably managing a particular forest tract means determining, in a tangible way, how to use it today to ensure similar benefits, health and productivity in the future. SFM is a system of management that guarantees continuous harvesting of forest resources (FAO 2001). It is governed by operational rules and regulations, allows the inexhaustible or everlasting existence of forest resources for future benefits and advantages and seeks the promotion of long life survival of the forest (Pampka 2005). SFM has potential to eradicate poverty, reduce land degradation, increase food security, and access to safe drinking water and provide affordable energy and other benefits. Managers, policy makers and all stakeholders in the forestry sub-sector need to collaborate and manage Nigerian

forest resources judiciously to be able to avert the imminent problems of deforestation.

Conclusion and recommendation

This study examined the rate of timber harvesting in a tropical rainforest ecosystem of southwestern Nigeria using Ondo State, Nigeria as a case study. The results indicated that virtually all indigenous tree species are now exploited as timbers from the reserves and free areas. There is sharp reduction in the availability of the most economic tropical hardwood species, so the lesser utilized ones are now in the timber market competing with the economic ones. Number of stems and species exploited from the free areas for the three-year period was discovered to be more than what was exploited from the reserves in the four zones selected for this study. The volume of trees exploited in the reserves was also less than what came out of the free areas for the three-year period. This was attributed to the fact that there were no stringent conditions attached to logging in the free areas as in the reserves where all activities within are controlled by the State Department of Forestry. Loggers only pay necessary fees as stipulated in forest tariff on logs to be felled in the free areas but this is lower than the cost of planting and nurturing another tree for replacement. This is very inimical to sustainable forest management. The tropical rainforest is therefore on the verge of total disappearance. The implications of this on rural livelihood, wood based industries; biodiversity conservation and environmental sustainability are very serious. So, SFM is potentially viable to reduce, if it cannot totally curb, this menace.

The following recommendations could effect the actualization of the principles of SFM in Nigeria: (1) proper forest governance, (2) eradication of chronic corruption and bribery, (2) campaign against all illegal activities in the forest estates, (4) provision of adequate fund to Forestry Department for effective monitoring and patrol, (5) encouraging community based forest management system, (6) review of the present obsolete forest laws, and (7) aggressive plantation development by the public and government.

References

Adekunle VAJ. 2006. Conservation of tree species diversity in tropical rainforest ecosystem of southwest Nigeria. *Journal of Tropical Forest Science* **18**(2): 91−101.

Adetula T. 2008. Challenges of sustainable forest management in Ondo State: Community based forest management system as a panacea. In: Onyekwelu, JC., Adekunle, VAJ and Oke, DO (eds), *Research for development in forestry, forest products and natural resources management*. The 1st National Conference of the Forest and Forest Products Society held at the Federal University of Technology, Akure, Nigeria, 16th–18th April, 2008. P242-247

Agbeja BO, Adesoye PO, Adu-Anning C, Abdoulaye T. 2005. Assessment of joint forest management practices in West Africa (Case study of Nigeria, Ghana and Niger). *Nigeria Journal of Forestry,* **35**(1): 32−40.

Akindele SO, Fuwape JA. 1998. Wood based industrial sector review submitted to Forestry Monitoring and Evaluation Coordinating Unit (FORMECU), the Federal Department of Forestry, Abuja, Nigeria. pp 77

Briner JD. 2004. Strong policy through National Consensus: Canada's Forestry Policy Experiment. In: *the Proceedings of the Conference on Policy Instruments for Safeguarding Forest Biodiversity – Legal and Economic Viewpoints*. The Fifth International BIOECON Conference, 15th−16th January 2004, House of Estates, Helsinki / Working Papers of the Finnish Forest Research Institute 1, ed. P. Horne et al., Finnish Forest Institute, Helsinki, pp. 131-142.

Brown KA, Gurevitch J. 2004. Long-term impacts of logging on forest diversity in Madagascar. *PNAS,* **101**(16): 6045−6049.

Falaye TA, Oluyege AO, Olufemi B, Fuwape JA. 2006. Timber harvesting pattern in the forests of Ekiti State, Nigeria from 1996-2001. In: *Proceedings of 2nd Annual Conference of School of Agriculture and Agricultural Technology*, Federal University of Technology, Akure, Nigeria, 24th May, 2006. pp 87-93.

FAO. 2001. Criteria and indicators for sustainable forest management: A compendium. Paper compiled by Froylán Castañeda, Christel Palmberg-Lerche and Petteri Vuorinen, May 2001. Forest Management Working Papers 5. Forest Resources Development Service, Forest Resources Division. FAO, Rome.

FORMECU (Forestry Monitoring Evaluating Coordinating Unit). 1999. Forest Resources Study, Nigeria. Overview Revised National Report. Volume 1. 108p

Fuwape JA. 2001. The impacts of forest industries and wood utilization on the environment. *Journal of Tropical Forest Resources* **17**(2): 78–90.

Ogunlade AB. 1993. The Needed Strategies and Problems of Industrial Plantation Development in Nigeria. In: Oduwaye EA. (editor), *Proceeding of 23rd Ann. Conf. of FAN*, Dec., 1993, p87

Okpo 1996. Personal communication. In: Meregini AOA (ed.), *Timber Production in Cocoa Based Agroforestry Systems in Parts of Abia State, Nigeria*. Proceedings of the 25th Annual Conference of the Forestry Associations of Nigeria. pp 103.

Olajide O, Etigale EB, Udofia SI. 2008. Wood-based industries and sustainable production of industrial wood raw material in Nigeria. In: Onyekwelu JC, Adekunle VAJ, Oke DO. (eds.), *Research for development in forestry, forest products and natural resources management*. The 1st National Conference of the Forest and Forest Products Society held at the Federal University of Technology, Akure, Nigeria, 16th–18th April, 2008. Pg212-215

Onyekwelu JC, Adekunle VAJ, Adeduntan SA. 2005. Does Tropical Rainforest Ecosystem Possess the Ability to Recover from Severe Degradation? In: L. Popoola, P. Mfon and P.I. Oni (eds.), *Sustainable Forest Management in Nigeria: Lessons and Prospects*, Proceeding of the 30th Annual Conference of the Forestry Association of Nigeria, Kaduna, Nigeria. 07th-11th Nov. 2005, p145-163.

Oyagade AO. 1997. Nigerian rainforest conservation: The challenge to the wood-based sector. In: *Proceedings of the 25th Annual Conference of the Forestry Associations of Nigeria*. pp 302-303.

Oyebo MA. 2006. History of forest management in Nigeria from 19th century to date. In: Ayobami T. S. (ed.), *Imperatives of space technology for sustainable forest management*. Proceedings of an international stakeholders' workshop sponsored by National Space Research and Development Agency held In Abuja, Nigeria between 27 and 28 March 2006., pg 1 – 14.

Pampka PM. 2005. Sustainable forest management: Opportunities and challenges for Nigeria. In: L. Popoola, P. Mfon and P.I. Oni (eds), *Sustainable Forest Management In Nigeria: Lessons and Prospects.*, Proceeding of the 30th Annual Conference of the Forestry Association of Nigeria, Kaduna, Nigeria. 07th−1th Nov. 2005, p1-17.

Reich PB, Bakken P, Carlson D, Frelich LE, Friedman SK, Grigal FD. 2001. Influence of logging, fire, and forest type on biodiversity and productivity in southern boreal forests. *Ecology,* **82**(10): 2731–2748.

Salami AT. 2006. Monitoring Nigerian forest with NigeriaSat-1 and other satellites. In: Ayobami T. S. (ed.) ,*Imperatives of space technology for sustainable forest management*. Proceedings of an international stakeholders' workshop sponsored by National Space Research and Development Agency held In Abuja, Nigeria between 27 and 28, March 2006, pg 26–61.

SPSS. 2003. Statistical package for social sciences, 12.0 for windows. SPSS Inc. Illinios, USA.